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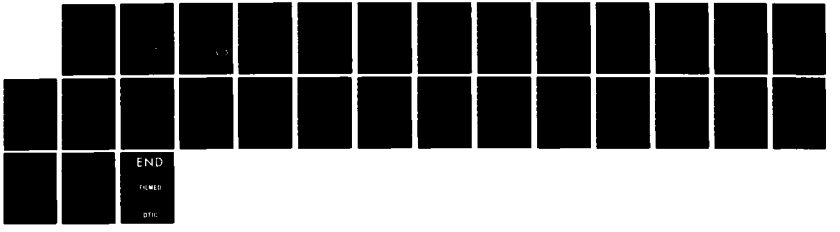

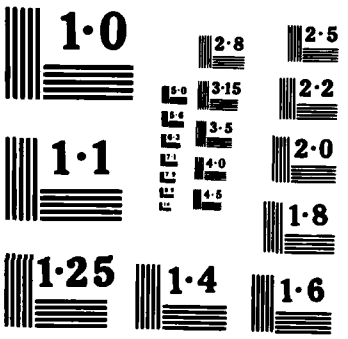

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SOUTH AUSTRALIA

TECHNICAL REPORT

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METCUT – A COMPUTER AIDED SYSTEM FOR MACHINING TECHNOLOGY

L.H.S. LUONG and R.W. AITCHISON

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METCUT - A COMPUTER AIDED SYTEM FOR MACHINING TECHNOLOGY

L.H.S. Luong, B.E.,Ph.D and R.W. Aitchison, Mech.Tech. Cert

S U M M A R Y

A computer aided method has been developed for providing cutting information for a number of machining operations. This method takes into account material as well as machine characterisitics.

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1. INTRODUCTION

This report describes a package of computer programs which has been developed for providing appropriate cutting data for a number of machining applications. The whole package was written in BASIC and can be run on PDP 11 computers running under RSTS operating systems. At present the package can provide cutting data for 9 operations, namely turning, face milling, end milling peripheral, end milling slotting, drilling, tapping, boring, part off and form tools and threading. Operations can be added or deleted from the package as desired. This package is also linked to TKDRAW which is an AEL developed CAD/CAM package for turned components. The package has also been implemented on a DATA GENERAL MV4000 computer, running under a AOS/VS operating system, at the Regency Park Community College.

The recommended cutting conditions for the various operations, based on the Machining Data Handbook, represent a tool life of approximately one to two hours of cutting time for most of the common alloys when using high speed steel tools. A tool life of 30 to 60 minutes is applicable for indexable-insert carbide tools.

2. ORGANISATION OF METCUT

The METCUT package consists of 5 files:

(1) EDIT.BAS: A program written in BASIC which is used for creating and editing the DATA.DAT file.

(2) CUTTEK.BAS: A program written in BASIC which is used to provide appropriate information on cutting conditions from the DATA.DAT file. This program is structured in blocks so more operations can be added on easily.

(3) MATLIS.DAT: A sequential data file which contains information on materials available. This file can be tailored to suit individual workshops.

(4) MACLIS.DAT: A sequential data file which contains information on machines and their characteristics. As with MATLIS.DAT, this file can be tailored to suit individual workshops.

(5) DATA.DAT: A random access file which contains information on machining data from the Handbook.

3. ORGANISATION OF THE MACHINING INFORMATION DATA FILE (DATA.DAT)

As previously mentioned, the information on machining technology is contained in a random access file called DATA.DAT. This file is a 200 rows by 10 columns array, D$(200,10). The size of the array can, however, be changed to suit individual needs.

The organisation of this file is shown in figure 1. Each column of the array is devoted to one operation, eg turning and drilling etc. The first row of the array, D$(0,1), is reserved for special information relating to individual operations, such as a range of hole diameters in drilling operations. Each material is allocated 10 rows (1 to 10) for cutting data relevant to that material. The last row (row 10) is reserved for information on unit horse power.

Each string, D$(I,J), represents one data line. The string, which is 256 characters long, is divided into 16 sections of 16 characters long (see

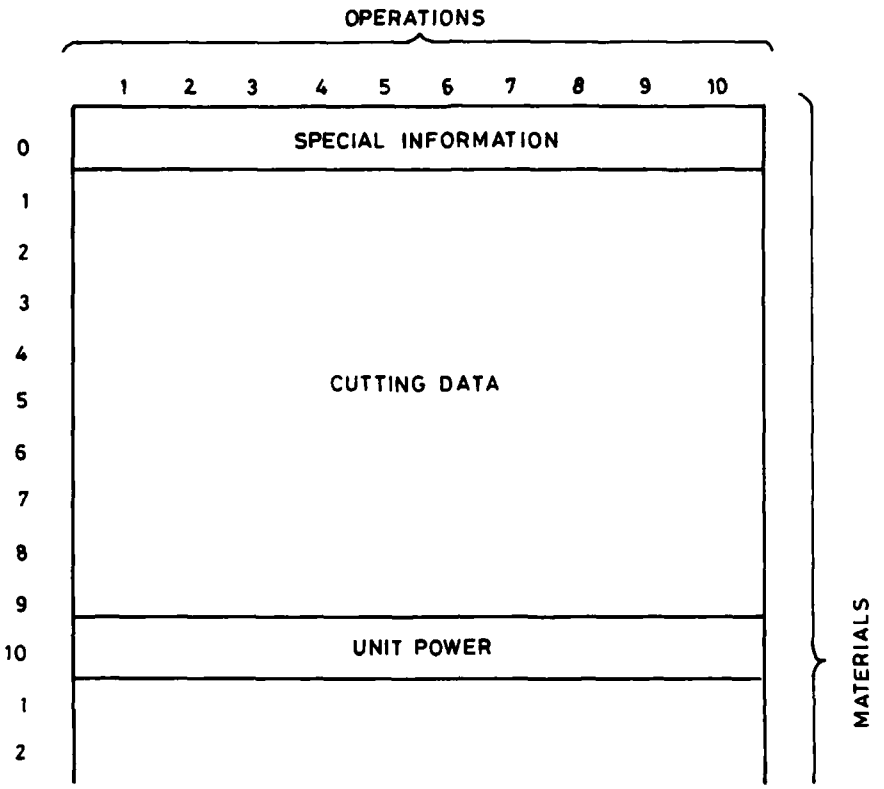

Figure 1. Organisation of the DATA.DAT file

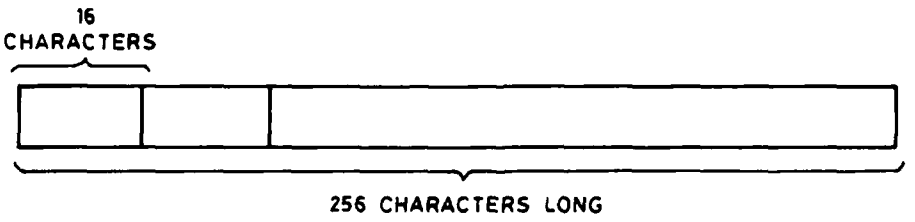

Figure 2. Structure of a string

figure 2). Thus, each string can contain a maximum of 16 data, and each data can have a maximum of 16 characters.

4. UNITS

In creating the data banks (DATA.DAT, MACLIS.DAT and MATLIS.DAT), the user can have a choice of either metric or imperial system of units. However, all data banks must have the same system of units. For example, if DATA.DAT is created in metric units, then MACLIS.DAT and MATLIS.DAT must also be in metric units.

Regardless of the units of the data banks, the METCUT package allows the cutting information to be obtained in either metric or imperial units.

The following are the units used in the METCUT package.

	Metric	Imperial
Surface speed	m/min	ft/min
Rotational speed	rpm	rpm
Depth of cut	mm	in
Width of cut	mm	in
Diameter	mm	in
Feed - for lathes	mm/rev	in/rev
- for mills	mm/min	in/min
Power	kW	horsepower
Unit power*	kW/cubic cm/min	horsepower/cubic in/min
Metal removal rate	cubic cm/min	cubic in/min

* Unit power is the power required to remove one units of a material per minute by an operation. These data were obtained from(ref.1).

5. METHODOLOGY

This section describes the procedures used in the CUTTEK.BAS program to extract appropriate cutting data from the DATA.DAT file.

(1) Input OPERATION name.

(2) Input MACHINE name.

(3) Check if operation is allowed on machine (eg turning is not allowed on a mill).

(4) Input MATERIAL AND BRINELL HARDNESS.

(5) Extract revelant cutting data and unit horsepower from DATA.DAT.

(6) Check if the cutting data are within the speed and feed ranges of the machine.

(7) Calculate power required for the operation, using the maximum recommended cutting conditions (equations (1), (2) and (3)).

(8) Check the power required against the power of the machine.

(9) If the machine power is less than the required power, reduce the metal removal rate by reducing speed and feed alternatively and go back to step 7.

(10) Print out cutting data.

Equations used in calculating the power required for each operation.

TURNING and BORING

$$HP = \frac{d * f * V * P}{E} \quad (1)$$

MILLING

$$HP = \frac{w * d * f * P}{E} \quad (2)$$

DRILLING

$$HP = \frac{A * f * P}{E} \quad (3)$$

where

HP is the power required at the machine motor,
d is the depth of cut,
f is the feed rate,
V is the surface speed,
P is the unit power,
w is the width of cut,
A is the surface area of the drilled hole,
E is the efficiency of the spindle drive. In this program, a value of 85% is used.

6. FEATURES OF THE MAIN PROGRAM (CUTTEK.BAS)

As previously mentioned, this program was structured in blocks so more operations can be added on easily. From the users point of view, the program has the following features:

(1) The program has full HELP facilities. If the user does not know the answer to a question, HELP facilities can be obtained by either typing "HELP" or just hitting the carriage return key.

(2) All names (operations, machines, materials) can be entered in either designated codes or names. If names are used, it is not necessary to type in the full name. Only sufficient characters are needed to distinguish one name from the other. See Appendix I for examples.

(3) The program allows the use of either metric or imperial system of units. In addition, units can also be changed during the running of the program. For example, in a situation the selected machine is calibrated in imperial units but stocks and tooling are in metric units, then the user can operate the program in imperial units to obtain cutting data to suit the selected machine, but the user can enter all stock and tooling sizes in metric units. Examples of this facility are shown in Appendix I.

(4) If, for some reasons, a selected machine can not be operated within the recommended cutting conditions, the user can nominate one cutting condition, eg speed, the program will then calculate the feed rate and depth of cut to suit the power of the selected machine.

7. FEATURES OF THE MACHINING DATA EDIT PROGRAM (EDIT.BAS)

This program provides editing facilities for the DATA.DAT file. Like the CUTTEK.BAS program, this program was also structured in blocks so that more operations can be easily added on. The program provides the following facilities:

(1) display cutting data for a selected operation and material.

(2) edit cutting data for a selected operation and material.

(3) edit a particular piece of information (eg speed) in a data line (string).

(4) copy a selected portion of the data file to a sequential file for hard copies.

(5) delete a whole section of the data file for a selected operation and material.

A typical working session with this program is shown in Appendix II.

8. FEATURES OF THE MATERIAL AND MACHINE DATA FILES

MACLIS.DAT and MATLIS.DAT are the two sequential files which contain information on material and machine characterisics respectively. Examples of these files are shown in Appendices III and IV. The built-in edit facilities of the computer can be used to create and edit these files.

When the METCUT package is implemented in a workshop, these two files are the only ones which have to be tailored to suit the materials and machines in the workshop. As the files are sequential, materials and machines can be easily added or deleted. Obviously, if new materials are added, then the DATA.DAT which contains information on cutting data has to be updated accordingly.

9. CONCLUSIONS

A package of computer programs in BASIC has been written to provide cutting data for various machining operations. These programs have been structured in blocks so that more operations can be easily added on.

Basic cutting data are stored in a data bank which has been created using information from the Machining Data Handbook. The programs extract appropriate information from the data bank, and then calculate the recommended cutting conditions, taking into account both material and machine characteristics, eg machine feed, speed range and machine power.

Implementation of this package in any workshop which has a computer with RSTS operating system can be easily carried out as information on materials and machines relevant to the workshop is contained in two sequential files. The package may run on other computers that have BASIC, depending on the amount of modifications needed to make the package work.

REFERENCES

No.	Author	Title
1	Machinability Data Centre	"Machining Data Handbook". Third Edition, Metcut Research Associates Inc., 1980

APPENDIX I

A TYPICAL WORKING SESSION WITH THE CUTTEK PROGRAM

(Note: users inputs are underlined)

```
RUN CUTTEK
          **************************************************
          *WELCOME TO MACHINING TECHNOLOGY PROGRAM*
          **************************************************
          HIT CARRIAGE RETURN FOR HELP
Do you wish to work with METRIC or IMPERIAL units <M OR I> ? I
IMPERIAL                                                    ---
Input OPERATION name or code <HELP???>       ?   <------ C/R for list
                                                         of operations

CODE            OPERATION
TUR             TURNING
FMI             FACE MILLING
EMP             END MILLING-PERIPHERAL
DRI             DRILLING
BOR             BORING
TAP             TAPPING
PRT             PARTOFF & FORM TOOLS
EMS             END MILLING-SLOTTING
THR             THREADING-SINGLE POINT
Input OPERATION name or code <HELP???>       ? T
                                              ---
THERE ARE  3  OPERATIONS
                        TURNING
                        TAPPING
                        THREADING-SINGLE POINT
WHICH OPERATION do you wish to use ? TU
TURNING                             ----
Input MACHINE name or code <HELP???>         ? C/R
                                               ---

CODE            MACHINE                 TYPE            HP
MAZ             MAZAK                   MILL            10.0
CIN             CINTIMATIC              MILL            3.00
S13             SCHAUBLIN13             MILL            2.00
S53             SCHAUBLIN53             MILL            4.00
TOS             TOS                     MILL            7.50
HUR             HURON                   MILL            3.00
MEX             MEX(VERTICAL)           MILL            13.4
KEA             KEARNS(BORER)           MILL            1.00
HNC             HARDINGE(NC)            LATHE           2.00
HXL             HARDINGE(NC)            LATHE           4.50
TAK             TAKISAWA(NC)            LATHE           14.75
TN1             TURN1(NC)               LATHE           6.0
WEI             WEILER                  LATHE           4.0
D13             DSG13                   LATHE           5.0
D17             DSG17                   LATHE           7.50
D25             DSG25                   LATHE           15.0
GRA             GRAZIANO                LATHE           4.8
VDF             VDF                     LATHE           7.4
SCH             SCHAERER                LATHE           15.0
```

```
M22             MACSON22                LATHE               15.0
M38             MACSON38                LATHE               25.0
S12             SCHAUBLIN120            LATHE               2.7
Input MACHINE name or code <HELP???>        ? MAZ
MAZAK                                        -----
                OPERATION :TURNING
                MACHINE   :MAZAK
THIS IS A MILL
THE SELECTED OPERATION DOES NOT MATCH THE MACHINE
Change OPERATION or MACHINE <O or M>        ? M
                                             ---
Input MACHINE name or code <HELP???>        ? HNC
HARDINGE(NC)                                 -----      Program checks
Input MATERIAL name or code <HELP???>       ? NC   <-- for incorrect
MATERIAL NOT FOUND                           ----      inputs
Input MATERIAL name or code <HELP???>       ? MS
MILD STEEL                                   ----
Input BRINELL HARDNESS                      ?    <-- Carriage return
MILD STEEL (1214)           120   BHN
MILD STEEL (S1010)          190   BHN
MILD STEEL (S1020)          190   BHN
MILD STEEL (XS1112)         210   BHN
MILD STEEL (BLACK)          220   BHN
Input BRINELL HARDNESS                      ? 190
                                             -----
Input MEAN WORKPIECE DIAMETER <INCHES>      ? 100 MM  <-- Metric Input
                                             --------
Input TOOL MATERIAL <Carbide or High speed steel> ? C
CARBIDE                                              ---
Input DEPTH OF CUT < .025  TO  .15  INCHES>  ? .03
                                             -----
                INPUTS
                ------
OPERATION               : TURNING
MACHINE                 : HARDINGE(NC)
MATERIAL                : MILD STEEL ( 190  BHN)
MEAN WORKPIECE DIA.     :   3.9370     INCHES
TOOL MATERIAL           : CARBIDE
DEPTH OF CUT            :   0.0300     INCHES
   RECOMMENDED CUTTING CONDITIONS
   ------------------------------
ROTATIONAL SPEED        :  438         RPM
SURFACE SPEED           :  451         FT/MIN
FEED RATE               :   0.0083     INCHES/REV
DEPTH OF CUT            :   0.0300     INCHES
TOOL GRADE              : C-6
Try ANOTHER DEPTH OF CUT <Y or N>   ? N
                                       ---
```

```
DO YOU WISH TO
                1. CHANGE OPERATION
                2. CHANGE MACHINE
                3. CHANGE MATERIAL
                4. CHANGE THE LOT
                5. EXIT
Input OPTION NUMBER < 1  TO  5  >              ? 1
                                                ---
Input OPERATION name or code <HELP???>         ? CIN  <-- Mistake
OPERATION NOT FOUND                             -----
Input OPERATION name or code <HELP???>         ? EMP
END MILLING-PERIPHERAL                          -----
                OPERATION :END MILLING-PERIPHERAL
                MACHINE   :HARDINGE(NC)
THIS IS A LATHE
THE SELECTED OPERATION DOES NOT MATCH THE MACHINE
Change OPERATION or MACHINE <O or M>           ? M
                                                ---
Input MACHINE name or code <HELP???>           ? CIN
CINTIMATIC                                      -----
Input CUTTER DIAMETER < .25  TO  2  INCHES>     ? 25 MM <-- Metric Input
                                                -------
Input NO. OF TEETH                             ? 3
                                                ---
Input TOOL MATERIAL <Carbide or High speed steel> ? C
CARBIDE                                                ---
Input WIDTH OF CUT < 0  TO  .98425  INCHES>     ? .9
                                                ----
Input DEPTH OF CUT < .015  TO  .05  INCHES>     ? .03
                                                -----
                INPUTS
                ------
OPERATION                 : END MILLING-PERIPHERAL
MACHINE                   : CINTIMATIC
MATERIAL                  : MILD STEEL ( 190  BHN)
CUTTER DIAMETER           :   0.9843     INCHES
NO. OF TEETH              :  3
TOOL MATERIAL             : CARBIDE
WIDTH OF CUT              :   0.9000     INCHES
DEPTH OF CUT              :   0.0300     INCHES
   RECOMMENDED CUTTING CONDITIONS
   ------------------------------
ROTATIONAL SPEED          :  1882        RPM
SURFACE SPEED             :  484         FT/MIN
FEED RATE                 :  33.8760     INCHES/MIN
DEPTH OF CUT              :   0.0300     INCHES
WIDTH OF CUT              :   0.9000     INCHES
TOOL GRADE                : C-6
NOTE: DEPTH OF CUT IS MEASURED PERPENDICULAR TO THE AXIS
Try ANOTHER DEPTH OF CUT <Y or N>   ? N
                                      ---
```

```
DO YOU WISH TO
               1. CHANGE OPERATION
               2. CHANGE MACHINE
               3. CHANGE MATERIAL
               4. CHANGE THE LOT
               5. EXIT
Input OPTION NUMBER < 1  TO  5  >            ? 1
                                              ---
Input OPERATION name or code <HELP???>       ? BOR
BORING                                        -----
Input MEAN BORE DIAMETER <INCHES>            ? 3
                                              ---
Input TOOL MATERIAL <Carbide or High speed steel> ? C
CARBIDE                                            ---
Input DEPTH OF CUT < .01  TO  .1  INCHES>    ? .1
                                              ----

               INPUTS
               ------

OPERATION                 : BORING
MACHINE                   : CINTIMATIC
MATERIAL                  : MILD STEEL ( 190  BHN)
NOMINAL BORE DIA.         :   3.0000     INCHES
TOOL MATERIAL             : CARBIDE
DEPTH OF CUT              :   0.1000     INCHES
   RECOMMENDED CUTTING CONDITIONS
   ------------------------------
ROTATIONAL SPEED          :  445         RPM
SURFACE SPEED             :  349         FT/MIN
FEED RATE                 :   6.6750     INCHES/MIN
DEPTH OF CUT              :   0.0280     INCHES
TOOL MATERIAL             : C-7
Try ANOTHER DEPTH OF CUT <Y or N>   ? N
                                         ---
DO YOU WISH TO
               1. CHANGE OPERATION
               2. CHANGE MACHINE
               3. CHANGE MATERIAL
               4. CHANGE THE LOT
               5. EXIT
Input OPTION NUMBER < 1  TO  5  >            ? 1
                                              ---
Input OPERATION name or code <HELP???>       ? FA
FACE MILLING                                  ----
Input CUTTER DIAMETER <INCHES>               ? 10
                                              ----
Input NO. OF TEETH                           ? 8
                                              ---
```

```
Input TOOL MATERIAL <Carbide or High speed steel> ? C
CARBIDE                                                    ---
Input WIDTH OF CUT < 0  TO  10  INCHES>      ? 10
                                             ----
Input DEPTH OF CUT < .025  TO  .15  INCHES>  ? .15
                                             -----
              INPUTS
              ------
OPERATION                 : FACE MILLING
MACHINE                   : CINTIMATIC
MATERIAL                  : MILD STEEL ( 190  BHN)
CUTTER DIAMETER           :  10.0000     INCHES
NO. OF TEETH              :  8
TOOL MATERIAL             : CARBIDE
WIDTH OF CUT              :  10.0000     INCHES
DEPTH OF CUT              :   0.1500     INCHES
   RECOMMENDED CUTTING CONDITIONS
   ------------------------------
ROTATIONAL SPEED          :  187         RPM
SURFACE SPEED             :  489         FT/MIN
FEED RATE                 :  11.9680     INCHES/MIN
DEPTH OF CUT              :   0.0250     INCHES
WIDTH OF CUT              :   6.8182     INCHES
TOOL GRADE                : C-7
* WIDTH OF CUT HAS BEEN REDUCED TO SUIT MACHINE
Try ANOTHER DEPTH OF CUT <Y or N>   ? N
                                      ---
DO YOU WISH TO
              1. CHANGE OPERATION
              2. CHANGE MACHINE
              3. CHANGE MATERIAL
              4. CHANGE THE LOT
              5. EXIT
Input OPTION NUMBER < 1  TO  5  >           ? 4
                                             ---
Do you wish to work with METRIC or IMPERIAL units <M OR I> ? M
METRIC                                                     ---
Input OPERATION name or code <HELP???>      ? F
FACE MILLING                                 ---
Input MACHINE name or code <HELP???>        ? MAZ
MAZAK                                        -----
Input MATERIAL name or code <HELP???>       ? AL
ALUMINIUM                                    ----
Input BRINELL HARDNESS                      ?
ALUMINIUM (5005)              60    BHN
ALUMINIUM (6061)              70    BHN
ALUMINIUM (L111)              135   BHN
Input BRINELL HARDNESS                      ? 70
                                             ----
```

```
Input CUTTER DIAMETER <MM>                          ? 80
                                                     ----
Input NO. OF TEETH                                  ? 4
                                                     ---
Input TOOL MATERIAL <Carbide or High speed steel> ? C
CARBIDE                                                ---
Input WIDTH OF CUT < 0  TO  80  MM>                 ? 75
                                                     ----
Input DEPTH OF CUT < .635  TO  6.35  MM>            ? 1
                                                     ---
              INPUTS
              ------
OPERATION                 : FACE MILLING
MACHINE                   : MAZAK
MATERIAL                  : ALUMINIUM ( 70  BHN)
CUTTER DIAMETER           :   80.00      MM
NO. OF TEETH              :  4
TOOL MATERIAL             : CARBIDE
WIDTH OF CUT              :   75.00      MM
DEPTH OF CUT              :    1.00      MM
   RECOMMENDED CUTTING CONDITIONS
   ------------------------------
ROTATIONAL SPEED          :  4000        RPM
SURFACE SPEED             :  1005        M/MIN
FEED RATE                 : 4999.99      MM/MIN
DEPTH OF CUT              :    1.00      MM
WIDTH OF CUT              :   75.00      MM
TOOL GRADE                : C-2
Try ANOTHER DEPTH OF CUT <Y or N>   ? N
                                       ---
DO YOU WISH TO
              1. CHANGE OPERATION
              2. CHANGE MACHINE
              3. CHANGE MATERIAL
              4. CHANGE THE LOT
              5. EXIT
Input OPTION NUMBER < 1  TO  5  >                   ? 1
                                                     ---
Input OPERATION name or code <HELP???>              ? D
DRILLING                                             ---
Input NOMINAL HOLE  DIAMETER < 1.5875  TO  50.8  MM>? 12
              INPUTS
              ------
OPERATION                 : DRILLING
MACHINE                   : MAZAK
MATERIAL                  : ALUMINIUM ( 70  BHN)
NOMINAL HOLE DIA.         :   12.00      MM
```

```
   RECOMMENDED CUTTING CONDITIONS
   ------------------------------
ROTATIONAL SPEED          :  2224        RPM
SURFACE SPEED             :  83          M/MIN
FEED RATE                 :  395.43      MM/MIN
TOOL MATERIAL             : HSS M1 M10
Try ANOTHER HOLE DIAMETER  <Y or N>   ? N
                                        ---

DO YOU WISH TO
               1. CHANGE OPERATION
               2. CHANGE MACHINE
               3. CHANGE MATERIAL
               4. CHANGE THE LOT
               5. EXIT
Input OPTION NUMBER < 1  TO  5  >            ? 4
                                              ---
Do you wish to work with METRIC or IMPERIAL units <M OR I> ? M
METRIC                                                      ---
Input OPERATION name or code <HELP???>       ? TU
TURNING                                       ----
Input MACHINE name or code <HELP???>         ? D13
DSG13                                         -----
Input MATERIAL name or code <HELP???>        ? BRA
BRASS                                         -----
Input BRINELL HARDNESS                       ? 120
                                              -----
Input MEAN WORKPIECE DIAMETER <MM>           ? 25
                                              ----
Input TOOL MATERIAL <Carbide or High speed steel> ? C
CARBIDE                                            ---
THE RECOMMENDED SPEED IS OUTSIDE THE MACHINE RANGE
SPEED RANGE OF DSG13 < RPM >:
 31            1400
RECOMMENDED SPEED RANGE < RPM >:
 4271          4950
                                                    Can select speed
DO YOU WISH TO CHOOSE YOUR OWN SPEED < Y OR N >? Y <-- or feed outside
                                                ---    recommended range
Input SPEED < 31  TO  1400  RPM>             ? 1400
                                              ------
Input DEPTH OF CUT <MM>                      ? 4
                                              ---
               INPUTS
               ------
OPERATION                 : TURNING
MACHINE                   : DSG13
MATERIAL                  : BRASS ( 120  BHN)
MEAN WORKPIECE DIA.       :   25.00      MM
TOOL MATERIAL             : CARBIDE
DEPTH OF CUT              :    4.00      MM
```

```
        CUTTING CONDITIONS
        ------------------
ROTATIONAL SPEED          :  1400        RPM
SURFACE SPEED             :  109         M/MIN
FEED RATE                 :    0.21      MM/REV
DEPTH OF CUT              :    4.00      MM
TOOL GRADE                : C-2
WARNING: THE ABOVE CUTTING CONDITIONS ARE OUTSIDE THE RECOMMENDED RANGE
Try ANOTHER DEPTH OF CUT <Y or N>   ? N
                                      ---
DO YOU WISH TO
               1. CHANGE OPERATION
               2. CHANGE MACHINE
               3. CHANGE MATERIAL
               4. CHANGE THE LOT
               5. EXIT
Input OPTION NUMBER < 1  TO  5  >            ? 5
                                              ---
Ready
```

APPENDIX II

A TYPICAL WORKING SESSION WITH THE EDIT PROGRAM

(Note: users inputs are underlined)

```
RUN EDIT
                    EDIT PROGRAM
          HIT CARRIAGE RETURN FOR HELP
ENTER OPERATION?        <------ C/R For list of operations
CODE          OPERATION
TUR           TURNING
FMI           FACE MILLING
EMP           END MILLING- PERIPHERAL
DRI           DRILLING
BOR           BORING
TAP           TAPPING
PRT           PARTOFF & FORM TOOLS
EMS           END MILLING- SLOTTING
THD           THREADING-SINGLE POINT
ENTER OPERATION? TUR
                 -----
ENTER MATERIAL?
CODE    MATERIAL                    GRADE              BHN HARDNESS
MS      MILD STEEL                  1214               120
-       MILD STEEL                  S1010              190
-       MILD STEEL                  S1020              190
-       MILD STEEL                  XS1112             210
-       MILD STEEL                  BLACK              220
HTS     HIGH TENSILE STEEL          BS1407             190
-       HIGH TENSILE STEEL          MST                300
-       HIGH TENSILE STEEL          X4150S(EN25T)      320
TS      TOOL STEEL                  EN39B              270
ASS     AUSTENITIC STAINLESS        316                185
MSS     MARTENSITIC STAINLESS       431                300
PHS     PRE. HARDEN. STAINLESS      ARMCO17-4PH        370
ALU     ALUMINIUM                   5005               60
-       ALUMINIUM                   6061               70
-       ALUMINIUM                   L111               135
BRO     BRONZE                      PB1C               160
-       BRONZE                      AS H12             170
BRA     BRASS                       AUS.ALLOY302       120
-       BRASS                       AUS.ALLOY303       120
COP     COPPER                      AS H91 C101        95
MAC     GLASS-CERAMIC MACHINABLE    MACOR              226
GCI     CAST IRON                   GREY               180
STM     STAR MOLD                   P20 P21            175
HSS     HIGH SPEED STEEL            M3 CLASS 2         230
```

```
ENTER MATERIAL? MS
                ----
OPERATION SELECTED: TURNING
MATERIAL SELECTED:  MILD STEEL
                    THERE ARE FIVE OPTIONS:
                    1. DISPLAY DATA LINES
                    2. EDIT DATA LINES
                    3. EDIT COLUMN OF A PARTICULAR LINE
                    4. COPY THE SELECTED PORTION OF THE DATA
                       BASE TO A SEQUENTIAL FOR HARD COPIES
                    5. DELETE WHOLE SECTION OF THE DATA BASE
                       FOR THE OPERATION & MATERIAL SELECTED
ENTER OPTION NUMBER? 1
                    ---
                         DISPLAY LINES MODE
                  OPERATION: TURNING;  MATERIAL: MILD STEEL
                  HIT RETURN TO TERMINATE SESSION
ENTER LINE NO. OF THE FIRST LINE TO BE DISPLAYED? 1
                                                   ---
ENTER TOTAL NUMBER OF LINES TO BE DISPLAYED? 10
LINE NO.  1                                   ----
85 .150 145 .015 M2 M3 550 .020 C-6
LINE NO.  2
125 .025 185 .007 M2 M3 700 .007 C-7
LINE NO.  3
125 .150 120 .015 M2 M3 485 .020 C-6
LINE NO.  4
175 .025 160 .007 M2 M3 625 .007 C-7
LINE NO.  5
175 .150 100 .015 M2 M3 450 .020 C-6
LINE NO.  6
225 .025 130 .007 M2 M3 550 .007 C-7
LINE NO.  7
225 .150 80 .015 M2 M3 400 .020 C-6
LINE NO.  8
275 .025 110 .007 M2 M3 490 .007 C-7
LINE NO.  9
LINE NO.  10
85 300 1.25 300 372 1.55                          C/R terminates
ENTER LINE NO. OF THE FIRST LINE TO BE DISPLAYED? <-- the current
CURRENT OPERATION:  TURNING                       option
CURRENT MATERIAL:   MILD STEEL
DO YOU WISH TO :
   1. CHANGE TO ANOTHER MODE (EG. EDIT TO DISPLAY)?
      OPERATION AND MATERIAL STAY THE SAME.
   2. CHANGE TO ANOTHER MATERIAL?
      OPERATION STAYS THE SAME.
   3. CHANGE TO ANOTHER OPERATION?
   4. TERMINATE THE PROGRAM?
```

```
ENTER OPTION NUMBER? 1
                     ---
OPERATION SELECTED: TURNING
MATERIAL SELECTED:  MILD STEEL
                    THERE ARE FIVE OPTIONS:
                    1. DISPLAY DATA LINES
                    2. EDIT DATA LINES
                    3. EDIT COLUMN OF A PARTICULAR LINE
                    4. COPY THE SELECTED PORTION OF THE DATA
                       BASE TO A SEQUENTIAL FOR HARD COPIES
                    5. DELETE WHOLE SECTION OF THE DATA BASE
                       FOR THE OPERATION & MATERIAL SELECTED
ENTER OPTION NUMBER? 2
                     ---
                         EDIT DATA LINES MODE
                  OPERATION: TURNING;  MATERIAL: MILD STEEL
                  HIT RETURN TO TERMINATE SESSION
ENTER LINE NUMBER TO BE EDITED?  <------ C/R terminates the
CURRENT OPERATION:  TURNING              current option
CURRENT MATERIAL:   MILD STEEL
DO YOU WISH TO :
   1. CHANGE TO ANOTHER MODE (EG. EDIT TO DISPLAY)?
      OPERATION AND MATERIAL STAY THE SAME.
   2. CHANGE TO ANOTHER MATERIAL?
      OPERATION STAYS THE SAME.
   3. CHANGE TO ANOTHER OPERATION?
   4. TERMINATE THE PROGRAM?
ENTER OPTION NUMBER? 1
                     ---
OPERATION SELECTED: TURNING
MATERIAL SELECTED:  MILD STEEL
                    THERE ARE FIVE OPTIONS:
                    1. DISPLAY DATA LINES
                    2. EDIT DATA LINES
                    3. EDIT COLUMN OF A PARTICULAR LINE
                    4. COPY THE SELECTED PORTION OF THE DATA
                       BASE TO A SEQUENTIAL FOR HARD COPIES
                    5. DELETE WHOLE SECTION OF THE DATA BASE
                       FOR THE OPERATION & MATERIAL SELECTED
ENTER OPTION NUMBER? 3
                     ---
                         EDIT COLUMNS MODE
                  OPERATION: TURNING;  MATERIAL: MILD STEEL
                  HIT RETURN TO TERMINATE SESSION
ENTER LINE NUMBER? 2
                     ---
```

```
LINE NO.  2
125 .025 185 .007 M2 M3 700 .007 C-7
ENTER COLUMN NO. TO BE EDITED?  <---,-- C/R terminates the
                                    ≡   current option
ENTER LINE NUMBER?  <---------------'
CURRENT OPERATION:  TURNING
CURRENT MATERIAL:   MILD STEEL
DO YOU WISH TO :
   1. CHANGE TO ANOTHER MODE (EG. EDIT TO DISPLAY)?
      OPERATION AND MATERIAL STAY THE SAME.
   2. CHANGE TO ANOTHER MATERIAL?
      OPERATION STAYS THE SAME.
   3. CHANGE TO ANOTHER OPERATION?
   4. TERMINATE THE PROGRAM?
ENTER OPTION NUMBER? 1
                    ---
OPERATION SELECTED: TURNING
MATERIAL SELECTED:  MILD STEEL
                    THERE ARE FIVE OPTIONS:
                    1. DISPLAY DATA LINES
                    2. EDIT DATA LINES
                    3. EDIT COLUMN OF A PARTICULAR LINE
                    4. COPY THE SELECTED PORTION OF THE DATA
                       BASE TO A SEQUENTIAL FOR HARD COPIES
                    5. DELETE WHOLE SECTION OF THE DATA BASE
                       FOR THE OPERATION & MATERIAL SELECTED
ENTER OPTION NUMBER? 4
                    ---
OPERATION SELECTED: TURNING
MATERIAL  SELECTED: MILD STEEL
ENTER FILE NAME? TURN.DAT
                ----------
DATA HAVE BEEN COPIED TO FILE TURN.DAT
CURRENT OPERATION:  TURNING
CURRENT MATERIAL:   MILD STEEL
DO YOU WISH TO :
   1. CHANGE TO ANOTHER MODE (EG. EDIT TO DISPLAY)?
      OPERATION AND MATERIAL STAY THE SAME.
   2. CHANGE TO ANOTHER MATERIAL?
      OPERATION STAYS THE SAME.
   3. CHANGE TO ANOTHER OPERATION?
   4. TERMINATE THE PROGRAM?
ENTER OPTION NUMBER? 4
                    ---
Ready
```

APPENDIX III

A TYPICAL LISTING OF THE MACHINE DATA FILE

****
* MACHINE FILE *
****

CODE	MACHINE	TYPE	HP	S1	S2	F1	F2	P1	P2
MAZ	MAZAK	MILL	10.0	25	4000	0.039	196.85	0	0
CIN	CINTIMATIC	MILL	3.0	85	3000	0.000	1000.00	0	0
S13	SCHAUBLIN1	MILL	2.0	58	2000	0.470	15.75	0	0
S53	SCHAUBLIN5	MILL	4.0	38	1510	0.470	41.30	0	0
TOS	TOS	MILL	7.5	32	1400	0.406	52.00	0	0
HUR	HURON	MILL	3.0	30	2066	0.062	30.0	0	0
MEX	MEX	MILL	13.4	28	1300	0.050	42.08	0	0
KEA	KEARNS	MILL	1.0	6	748	0.490	4.88	0	0
HNC	HARDINGE1	LATHE	2.0	150	3000	0.000	0.20	0.001	0.20
HXL	HARDINGE2	LATHE	4.5	35	3500	0.000	1.00	0.001	0.20
TAK	TAKISAWA	LATHE	14.8	65	2000	0.000	0.79	0.001	0.78
TN1	TURN1(NC)	LATHE	6.0	32	1600	0.000	0.01	0.001	0.01
WEI	WEILER	LATHE	4.0	12	2800	0.001	0.05	0.020	0.66
D13	DSG13	LATHE	5.0	31	1400	0.001	0.06	0.031	1.00
D17	DSG17	LATHE	7.5	8	720	0.001	0.07	0.156	5.00
D25	DSG25	LATHE	15.0	7	600	0.001	0.08	0.156	8.00
GRA	GRAZIANO	LATHE	4.8	45	1500	0.000	0.02	0.045	0.33
VDF	VDF	LATHE	7.4	28	1250	0.000	0.04	0.017	4.00
SCH	SCHAERER	LATHE	15.0	9	1800	0.003	0.04	0.017	4.00
M22	MACSON22	LATHE	15.0	15	560	0.004	0.06	0.021	1.50
M38	MACSON38	LATHE	25.0	7	316	0.005	0.12	0.021	1.50
S12	SCHAUBLIN	LATHE	2.7	105	1750	0.001	0.02	0.016	0.25

Notes: HP - horsepower
S1 - minimum speed
S2 - maximum speed
F1 - minimum feed
F2 - maximum feed
P1 - minimum pitch
P2 - maximum pitch

APPENDIX IV

A TYPICAL LISTING OF THE MATERIAL DATA FILE

```
**********************
* MATERIAL FILE *
**********************
```

NO,	CODE,	MATERIAL,	GRADE,	BHN HARDNESS
1,	MS,	MILD STEEL,	1214,	120
-,	-,	MILD STEEL,	S1010,	190
-,	-,	MILD STEEL,	S1020,	190
-,	-,	MILD STEEL,	XS1112,	210
-,	-,	MILD STEEL,	BLACK,	220
2,	HTS,	HIGH TENSILE STEEL,	BS1407,	190
-,	-,	HIGH TENSILE STEEL,	MST,	300
-,	-,	HIGH TENSILE STEEL,	X4150S(EN25T),	320
3,	TS,	TOOL STEEL,	EN39B,	270
4,	ASS,	AUSTENITIC STAINLESS,	316,	185
5,	MSS,	MARTENSITIC STAINLESS,	431,	300
6,	PHS,	PRE. HARDEN. STAINLESS,	ARMCO17-4PH,	370
7,	ALU,	ALUMINIUM,	5005,	60
-,	-,	ALUMINIUM,	6061,	70
-,	-,	ALUMINIUM,	L111,	135
8,	BRO,	BRONZE,	PB1C,	160
-,	-,	BRONZE,	AS H12,	170
9,	BRA,	BRASS,	AUS.ALLOY302,	120
-,	-,	BRASS,	AUS.ALLOY303,	120
10,	COP,	COPPER,	AS H91 C101,	95
11,	MAC,	GLASS-CERAMIC MACHINABLE,	MACOR,	226
12,	GCI,	CAST IRON,	GREY,	180
13,	STM,	STAR MOLD,	P20 P21,	175
14,	HSS,	HIGH SPEED STEEL,	M3 CLASS 2,	230

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